Finding Key BIO Traits in BIOgeochemical Modelling

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GEOMAR

DynaTrait

Motivation

Uncertainties about marine biotic processes and their interactions with the global carbon cycle remain major obstacles for understanding past and predicting future climate change.

Representations of plankton organisms in biogeochemical models are at odds with observed behaviour. Optimality-based formulations of phyto- and zooplankton (Fig. 1) are more realistic without increasing the number of model parameters.

We have implemented optimality-based formulations for zooplankton and diazotrophic and non-diazotrophic phytoplankton in the UVic Earth System model (Figs. 1 and 2).

The modified UVic-ESCM simulates variable stoichiometry and is used for sensitivity (Fig. 3) and long-term analyses (Fig. 5)

Optmality-Based Plankton in the UVic-ESCM

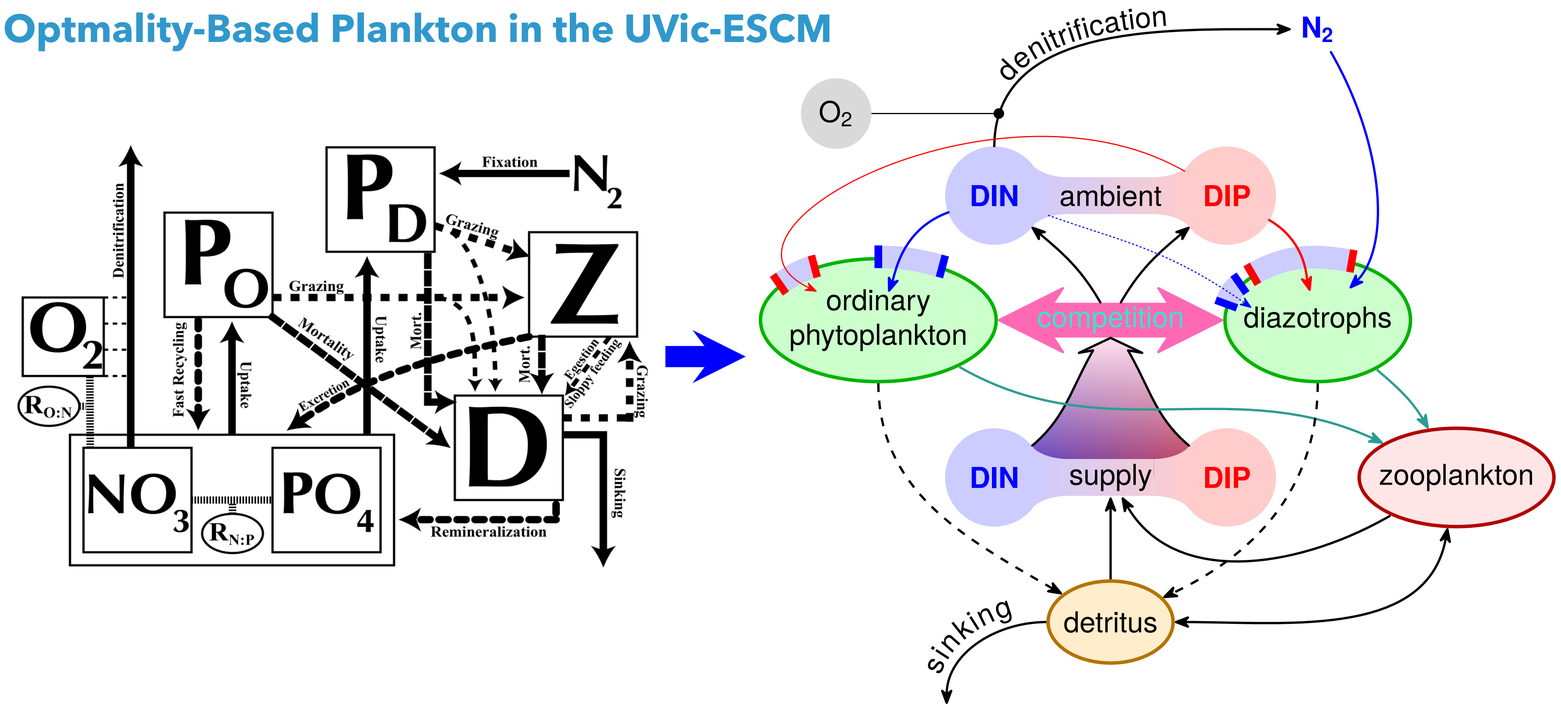
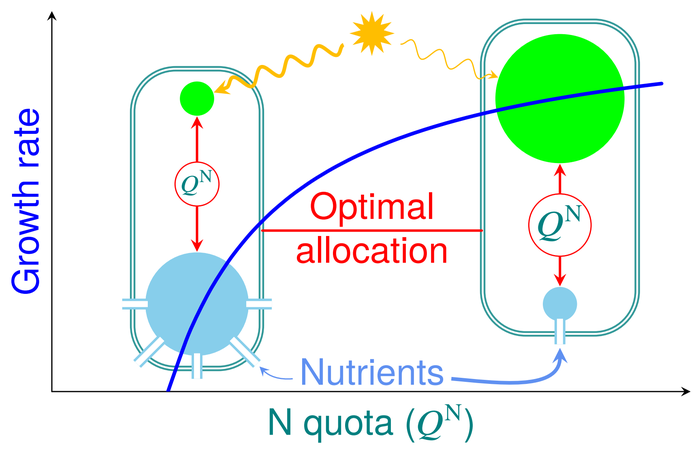


Fig. 2: Optimality-based formulations (right) replace the original plankton compartments (left, Keller et al., 2012) in the UVic-ESCM.

Optimality-Based Formulations



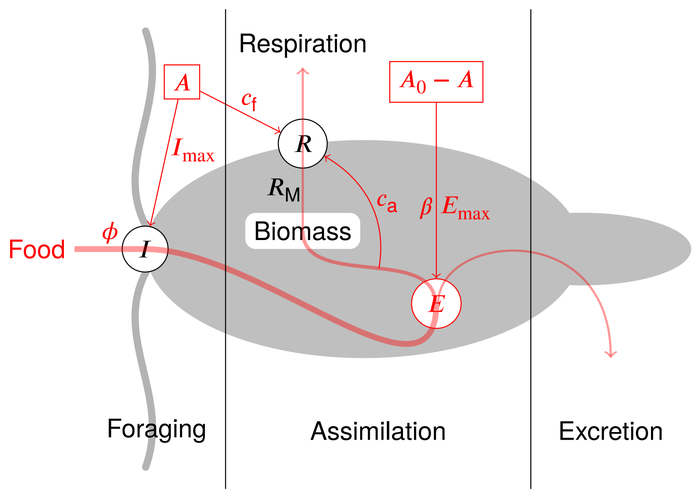


Fig. 1: Optimality-based phytoplankton (top, Pahlow et al., 2013) and zooplankton (bottom, Pahlow & Prowe, 2010) compartments for the plankton model shown in Fig. 2 (right).

Conclusions

Optimality-based biogeochemistry …

- allows sensitivity analyses related to behaviour of "real" organisms
- helps identify knowledge-gaps and misconceptions in marine biogeochemistry
- improves predicted patterns in deep-water nutrient stoichiometry
- reveals high sensitivity to physiological traits missing in other models

Sensitivity to phytoplankton physiology

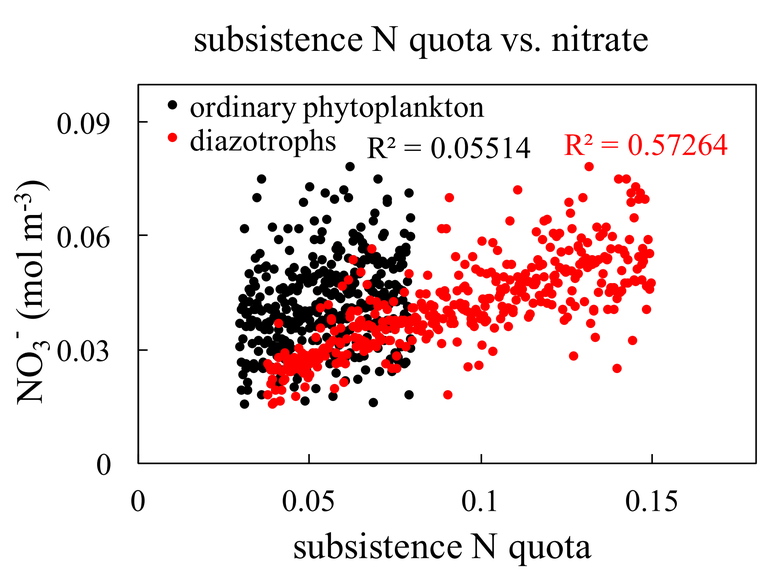


Fig. 3: Diazotroph subsistence N quota is a key determinant of the global fixed-N inventory in the UVic-ESCM.

- The global N inventory is highly sensitive to diazotroph N subsistence quota (Fig. 3).
- This trait does not exist in most biogeochemical models.
- The optimality-based compartments improve predicted patterns in deep-water N:P ratios (Fig. 5).

Observed deep-water N:P.

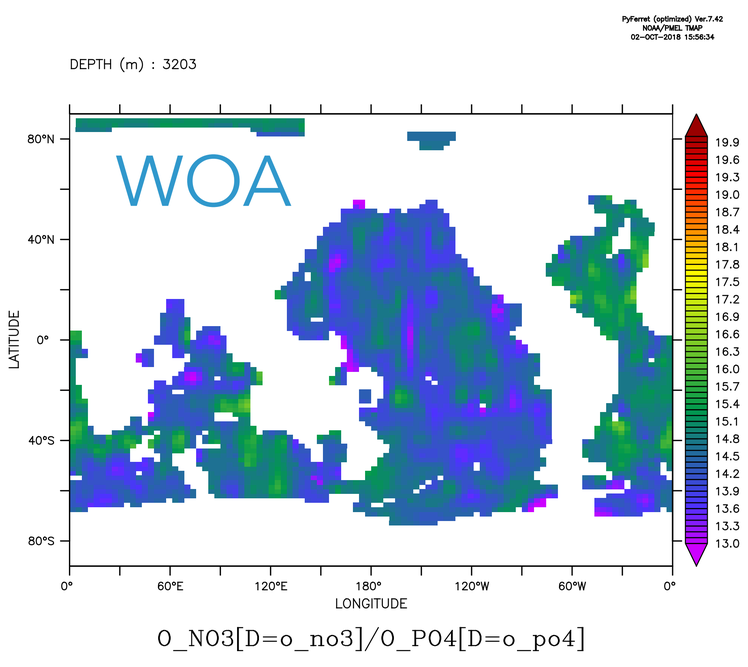


Fig. 4: Deep-water N:P in the World Ocean Atlas (2013).

Deep-water N:P with original and optimality-based plankton in the UVic-ESCM.

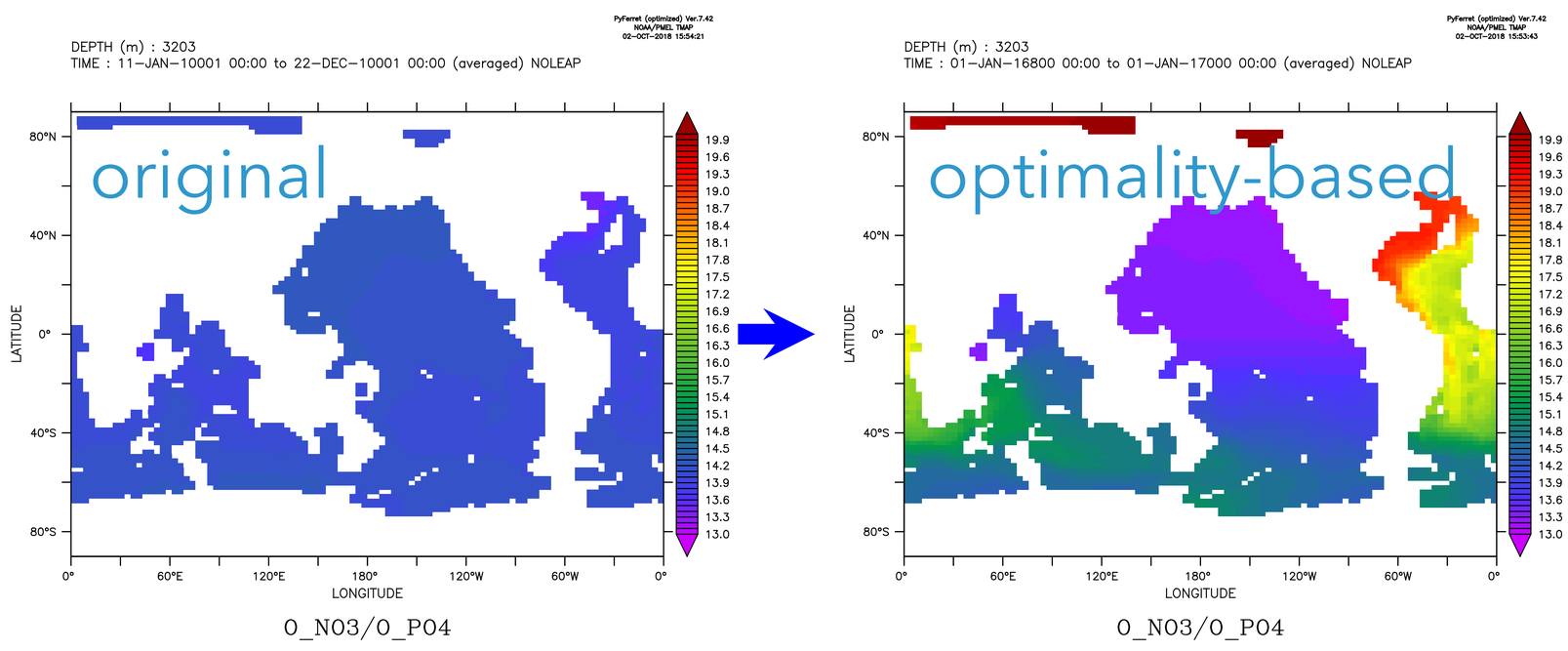


Fig. 5: Deep-water N:P gradients are reversed and underestimated with the original plankton (left). Deep N:P gradients are better represented with optimality-based plankton, although N:P is overestimated in the deep North Atlantic.

References

Keller, D. P. et al. (2012). *Geosci. Model Dev.* 5: 1195.

Pahlow, M. & A. E. F. Prowe (Mar. 2010). *Mar. Ecol. Prog. Ser.* 403: 129.

Pahlow, M. et al. (2013). *Mar. Ecol. Prog. Ser.* 489: 1.